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ABSTRACT

The growing interest in the field of educational technology in the design of constructivist learning environments has led to a renewed examination of problem-based learning (PBL), an approach to instruction in which all learning results from students' efforts to solve a complex problem. Concurrent advances in technology make it possible to use this approach with a wider range of audiences than have traditionally used PBL, yet few guidelines exist for designers interested in creating computer-based PBL environments. This paper presents some of the lessons learned from the process of developing Alien Rescue, winner of the 2001 Learning Software Design Competition sponsored by the University of Minnesota. (Author)

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The Design of *Alien Rescue*, Problem-Based Learning Software for Middle School Science

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Abstract

The growing interest in the field of educational technology in the design of constructivist learning environments has led to a renewed examination of problem-based learning (PBL), an approach to instruction in which all learning results from students' efforts to solve a complex problem. Concurrent advances in technology make it possible to use this approach with a wider range of audiences than have traditionally used PBL, yet few guidelines exist for designers interested in creating computer-based PBL environments. This paper presents some of the lessons learned from the process of developing Alien Rescue, winner of the 2001 Learning Software Design Competition sponsored by the University of Minnesota.

Alien Rescue

Alien Rescue is a computer-based PBL program for use in sixth grade science classes. The primary learning objectives of *Alien Rescue* focus on the solar system and the scientific instruments used to investigate it, though the program offers ties to other areas of the curriculum, including writing and mathematics.

The science fiction premise of *Alien Rescue* takes students to a newly operational international space station where they become a part of a worldwide effort to rescue alien life forms. The program begins with the 7-minute long Opening Scenario, which presents the central problem of the program, and which students, acting as scientists, are asked to participate in solving. A spaceship carrying six species of aliens fleeing their own planetary system have arrived in Earth orbit. Their ship was damaged during their voyage, and except for their engines and computer databases, little of their technology continues to function. In order to survive, they must find new homes on worlds that can support their life forms. Having picked up Earth broadcasts, the aliens learned our languages with the intention of asking for our help to relocate to worlds in our solar system. However, when their life support failed completely, the aliens could only complete a distress message to be sent once they reached Earth orbit, then entered a state of suspended animation, where they must remain until they are safely relocated to suitable worlds.

Students are informed that they are just one of many teams of scientists participating in this rescue operation, and that their task is to determine the most suitable relocation site for each alien species. In order to solve this problem, students must engage in a variety of activities. They must learn about the aliens and identify the basic needs of each species. To do so, students search the Alien Computer, which they are informed was moved from the alien ship to the international space station so that they could conduct their research. They must then investigate the planets and moons of our solar system, searching them for possible matches with the needs of the aliens. Students gather this information in two ways. They can search the Solar System Database, a resource within the program containing information about the sun, nine planets, and ten of the large moons of our solar system. Then, to gather needed information that is missing from the Solar System Database, students can use a simulation within the program that allows them to design and launch probes to other worlds. Students interpret the data returned from these probes, applying the information they glean back to the problem. Finally, students must use the information they gather to select a new homeworld for each species and justify their decisions. They identify their choices and write a rationale for each choice in the Recommendation Form. To discourage students from developing a solution without time for adequate investigation, the Recommendation Form does not appear on screen until students have used the program for 300 minutes.

To support students as they work toward developing a solution, *Alien Rescue* offers the Expert Tool. This tool provides video of a character who is scientist working on the same problem as the students as he interacts with the resources within the program. The expert models his process as he works on finding a home for one of the species. He does not help students with the other species, nor does he direct them to work in a particular way. However, by making explicit the strategies an expert brings to bear as he works on the problem, the Expert Tool supports students in developing effective problem-solving strategies.

Alien Rescue is an example of a student-centered learning environment. Students are engaged in a complex task, but they determine and control their process. Yet they are not expected to determine this process or develop a

solution on their own. *Alien Rescue* was designed to be used in classrooms rather than as a product for home use, and we consider the social negotiation that occurs as students interact with their teacher and peers to be an essential source of support for learning through this program. The teacher, working as a facilitator, pushes students to articulate their planning and reasoning, challenges their misconceptions, promotes peer collaboration, and builds connections to a wide range of scientific topics. Peers provide support for the complexities of the environment and help each other to refine their understandings as they discuss/argue the merits of alternative solution plans.

Problem-Based Learning

PBL is an instructional approach in which learning occurs as a result of students' efforts to develop a solution to a complex problem. Instruction begins with the presentation of a problem situation. Students work in teams to identify problem constraints, form hypotheses, collect and analyze data, and develop a solution plan. Along the way, students discover that they need a great deal of factual information in order to understand the problem, determine all their options, and develop a viable solution. In order to collect it, they use the same tools experts would use: existing informational resources such as books and computer databases, and domain specific tools such as microscopes, calculators, or maps.

The literature on PBL has suggested a number of benefits for this approach, including high levels of intrinsic motivation (Albanese & Mitchell, 1993; Stepien, Gallagher, & Workman, 1993), enhanced problem-solving skills (Gallagher, Stepien, & Rosenthal, 1992; Williams, 1993), and more effective self-directed learning (Aspy, Aspy, & Quinby, 1993; Blumberg & Michael, 1992). Despite the potential for learning that PBL offers, the realization of these benefits is far from assured. The success of PBL depends on students' "willing cognition," their intrinsically motivated efforts to gather the information and develop the skills they need in order to create well-reasoned solutions. Without this investment of cognitive effort, students may fail to recognize the relevant nuances of the problem, neglect to identify pertinent learning needs, or rush to develop solutions that turn out to be non-viable. Establishing and maintaining this willing cognition in students must therefore be an overarching goal for designers of PBL programs.

Guidelines for the Design of PBL Programs

While the design of *Alien Rescue* was informed by both theory and research, a number of additional insights arose through the process of development and testing. In the remainder of this paper we share some of these insights in the belief that they can help to guide the design of future computer-based PBL environments. The following suggestions address issues related to the design of the central problem of a PBL program, the informational resources provided, the program interface, and the support materials for classroom teachers.

Develop an interesting and rich problem that creates a need for information and multiple applications of key strategies. The most important design task in the development of a PBL program is the creation of the central problem. This problem will affect students' willingness to take ownership over their process and learning. It will also determine what learning needs students identify and, as Stepien, Gallagher, and Workman (1993) point out, what information they must "run into" in order to solve the problem. To promote students' "willing cognition" and maximize the potential for learning, the central problem of a PBL program should have five characteristics. First, it should be *interesting* to the target audience in order to promote students' ownership over their process and solution. For example, in our early planning phase for *Alien Rescue*, we initially considered having students identify a world for human colonization. We eventually decided that students would find aliens more interesting and would therefore be more intrinsically motivated to invest cognitively in solving the problem.

Second, the problem needs to be *challenging*, so that a solution does not seem obvious. Students are accustomed to well-structured problems where all necessary information is presented in the problem itself, the problem has a single correct solution, and the time to solution is relatively brief. If students perceive that the problem is not challenging, they may fail to recognize the need for additional knowledge and "solve" the problem without fully understanding it. Once students believe that they have completed their work, they may be reluctant to invest further cognitive effort in developing a solution.

Third, the problem needs to be *manageable* so that students persist in their efforts to develop a solution. As students recognize the complexity of the problem, they may become frustrated if they believe that it is too difficult or that they cannot learn all they need to know in order to develop a solution. Balancing challenge with manageability and effectively communicating both to students can be quite difficult. In our testing with *Alien Rescue*, we have found that students generally recognize the challenge relatively quickly, but take some time to

recognize its manageability. With six species of aliens, each with a different set of needs, and nineteen worlds to consider as possible homes for them, the problem requires students to conduct a great deal of research, a fact which they recognize as they come to understand the problem. Early in the program we have seen some students express some apprehension and frustration as they experience uncertainty about what they should do and are unable to solve the problem quickly. This typically evaporates as students come to understand the resources within the program and begin to develop a process to work toward solution. What gets students over this hurdle and keeps them cognitively engaged is their interest in the problem and in the virtual environment in which the problem is set. In this way, the rich media and interesting tools provided within the program may serve to motivate students to persist long enough to recognize that they can manage the challenge the problem presents.

Fourth, the central problem of the PBL program should *cause students to recognize the need for information and skills*. When students recognize that they do not have all of the information they need, they seek it, and it is this effort to meet these learning needs that drives students' investigation and which results in their natural acquisition of key terminology, factual information, and concepts within the problem domain. Because students have determined the need for certain knowledge and have identified a method for acquiring that knowledge, all their learning is meaningful to them. It is therefore essential that the problem lead learners to recognize that they do not have all of the information they need to develop a solution.

Finally, the problem should *create multiple opportunities for students to apply the same problem-solving strategies* in order to encourage students to reflect on and refine them. In *Alien Rescue*, students must select homes for five species of aliens (the expert recommends a solution for the sixth). While the needs of each species are different and the conditions on each world vary, the process for developing a solution for each species is basically the same. Students must consider different factors and constraints, but they can apply the same problem-solving strategies. This gives students an opportunity to refine their process and reflect on what is effective.

Design miniature problems into the environment. PBL provides not only a problem but also a context in which that problem takes place. While it is impossible for designers to control all aspects of the PBL experience, it is possible to design small complexities into that context that learners must encounter in order to solve the problem. The need to cope with constraints, determine alternative resources for data collection, and interpret data provides challenges that encourage deep thinking and an ongoing need for the development of problem-solving strategies. This helps a PBL environment to reflect real world problem solving, where overcoming numerous hurdles is a common necessity. These miniature problems also provide opportunities for rich discussions on science.

One example of a miniature problem built into *Alien Rescue* occurs in the alien computer. Rather than using the names of elements to communicate the composition of their atmospheres, the aliens show spectrograms. Spectrograms show the spectral signature of an element; the spectrogram of each element is unique and universal. The aliens communicate this information using spectrograms ostensibly because they were unable to learn the English translation for elements. However, students this age have never encountered spectrograms and are confused by them when they see them in the alien computer, yet they recognize a need for the information these spectrograms communicate. A number of things happen in class as a result of this miniature problem. First, the teacher can decline to tell students how to get the information they need to interpret the spectrogram and instead use this problem as a vehicle for encouraging collaboration and peer interdependence. Second, it challenges students to investigate more deeply, actively exploring the environment to figure out how to solve this problem themselves. As some students do solve it, they become experts on this particular problem, and when their peers seek help they can provide it. Finally, these miniature problems provide a jumping off point for rich class discussions. For example, the spectrogram problem can lead to discussions on spectroscopy or starlight. The miniature problems within *Alien Rescue* can lead to class discussions on a wide variety of science topics, including radio waves, magnetic fields, Galileo and the moons of Jupiter, geological activity, supernova, ice, gravity, meteors, and atmospheres.

Provide access to all necessary information within the environment without suggesting the usefulness of that information in the development of a solution. One reason that teacher development of PBL programs is so difficult is that students must have access to an adequate number of resources to meet their learning needs, but not so many that they are overwhelmed and unable to find the information they need. By providing all necessary information within the program, designers of computer-based PBL programs can assure its accessibility. However, providing a single, well-structured informational resource can limit the range of considerations students make, suggesting a solution without requiring sufficient cognitive effort on the part of the learner.

Because one of our goals in Alien Rescue was to promote students' mindful search for useful information, we wanted to avoid providing resources that encouraged a passive page-turner mode of use, or which were structured to suggest certain solutions. To accomplish this, we used two strategies to maintain the complexity of

real-world problem solving and create a need for students to work purposefully. First, more information than is needed is included in the program so that students must discriminate between what is useful and what is not. For example, the alien computer contains information about the aliens' needs, but it also contains information about the uninhabited worlds in their solar system, their journey, and their languages. Second, the needed information is divided among multiple tools so that students must consider a variety of data sources. Some of these resources are purely informational, while others require students to conduct investigations to collect data. For example, the Solar System Database contains text and graphics, while the probe simulation requires students to design probes, launch them, and interpret the data returned from them. Taken together, these strategies encourage students to think about what information they need before conducting research so that they are not overwhelmed by irrelevant facts. This balance of accessibility and complexity makes it possible for learners to be successful within a challenging program.

Use spatial relationships to help users become familiar with the tools available within the environment. The large number of informational resources and organizational tools users need within a PBL environment presents a challenge for the design of the interface. Information buried several layers deep within the interface may never be found. By their very nature, the problems used in PBL occur within some context; a computer-based program can exploit this quality by creating a virtual setting for students' work. By structuring this virtual setting so that spatial relationships are established among the resources, the interface can help learners understand and remember how to access useful tools.

Alien Rescue contains thirteen tools, most with different purposes and interface features particular to themselves. To help learners understand the variety of these tools and their relationships, we created a two-level interface. The first level is the international space station, a futuristic virtual environment which consists of five rooms that learners can navigate among, using the arrow keys on their keyboards. These rooms contain resources students will only need for part of the program. The second level is the goggles interface. In the Opening Scenario, students are told to imagine that they are wearing goggles that provide access to a variety of tools throughout their work. Tabs along the sides and bottom of the screen provide access to these tools, and students can open and close them using the mouse. This two level interface creates relationships between the tools that supports students in discovering and remembering how to access the wide variety of resources available within the program. Our testing with *Alien Rescue* has shown that students are typically able to navigate easily among the various tools by the third day of class, quickly accessing the tools they need to conduct their work.

Create the need, opportunity, and support for collaboration. The need for information that is not instantly apparent, a rich context, and the occurrence of numerous small problems within a PBL program all add to the complexity of the task. Unable to handle this complexity individually, students naturally seek support. In *Alien Rescue*, we typically witness students first turning to their teachers for help. But when the classroom teacher refuses to solve their problems for them and instead directs them toward their peers, students begin to understand the value of collaboration. Allowing and encouraging a collaborative environment within the classroom leads students to see their peers as resources for dealing with difficulties, which in turn can enhance both learning and motivation.

Designers can only control the content of the computer-based programs they create; they exercise little control over the real-world contexts in which the program is used. Therefore designers can only create a need for collaboration. Providing the opportunity and support for collaboration is the responsibility of the classroom teacher. Support materials for teachers should therefore include strategies on how to encourage and support collaboration. The teacher's manual for *Alien Rescue* offers three strategies that teachers can use to support collaboration. First, as described above, teachers can redirect students' questions to their peers. This giving and receiving of help lays a groundwork for more complex forms of collaboration, such as shared planning and division of labor. As some students begin to develop ongoing collaborative relationships with a few peers, teachers can use a second strategy, peer modeling, to encourage greater collaboration among other students. In peer modeling, the teacher asks students who are successfully collaborating to describe their process to their classmates. Teachers may guide this description through the use of specific questions, but they make it clear that students developed and control their own process, and that there is more than one way to collaborate successfully. Through the use of peer modeling, teachers provide students with examples of the logistics of collaboration and legitimize it as a successful strategy for accomplishing complex tasks. Finally, teachers are encouraged to discuss the role of collaboration in the scientific community. One of the goals of *Alien Rescue* is to help students understand the real work of scientists, and that work is usually conducted within collaborative communities. Teachers can describe how scientists typically work in research teams, pooling their various areas of expertise and sharing the responsibility for the investigations they conduct. They can also explain the importance of scientists publishing their findings and building on the work of other scientists. Again, this strategy legitimizes collaboration by framing it as an aspect of the work of "real" scientists.

Designing effective PBL programs is a complicated affair, and this paper addresses only a few of the lessons learned through the process of designing *Alien Rescue*. As problem-based learning becomes a more widely accepted approach, more discussion is needed about effective design principles.

For more information on *Alien Rescue*, visit our website at www.alienrescue.com.

References

Albanese, M. A., & Mitchell, S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues. *Academic Medicine, 68*, 52-81.

Aspy, D. N., Aspy, C. B., & Quinby, P. M. (1993). What doctors can teach teachers about problem-based learning. *Educational Leadership, April*, 22-24.

Blumberg, P., & Michael, J. A. (1991). The development of self-directed learning behavior in a partially teacher-centered problem-based learning curriculum. *Teaching and Learning Medicine, 4*, 3-8.

Gallagher, S. A., Stepien, W. J., & Rosenthal, H. (1992). The effects of problem-based learning on problem solving. *Gifted Child Quarterly, 36*(4), 195-200.

Stepien, W. J., Gallagher, S. A., & Workman, D. (1993). Problem-based learning for traditional and interdisciplinary classrooms. *Journal for the Education of the Gifted, 16*(4), 338-357.

Williams, S. M. (1993). Putting case based learning into context: Examples from legal, business, and medical education. *Journal of the Learning Sciences, 2*, 367-427.

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